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## Collective construction of knowledge in the initial professional training for natural sciences

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### Abstract

Students from teaching courses, during their initial training, need to be introduced into the process of reformulation and resignification of knowledge for the construction of scientific and pedagogical knowledge which will be crucial for their future professional practices. The hypothesis is that this will only be achieved through collective activities that involve not only university students in their initial training and their professors, but also school teachers. This article reflects upon the contributions the activities developed by a Study Group, based on Fleck's epistemology, has made to the process of initial training in future teachers of the area of Science. The results indicate that these students, who are experiencing a qualified initiation to teaching, are feeling more motivated and better able to exercise their profession in the future.

### Keywords

Science teacher training; Ludwik Fleck epistemology; Collective construction of knowledge.

## La construcción colectiva del conocimiento en la formación profesional inicial en ciencias de la naturaleza

### Resumen

Los universitarios que estudian para impartir clases en secundaria, durante su formación inicial, necesitan ser introducidos en el proceso de reformulación y resignificación de

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conocimientos para la construcción de saberes científicos y pedagógicos que serán cruciales para el ejercicio profesional futuro. El presupuesto es que eso solamente se alcance por medio de actividades colectivas que involucren no solo a los académicos en formación inicial y sus formadores, sino también, a los profesores en ejercicio en la escuela básica. El presente artículo teje consideraciones sobre las contribuciones que las actividades desarrolladas en un Grupo de Estudio, al tener como referencial teórico la epistemología de Fleck, viene añadiendo al proceso de formación profesional inicial de futuros profesores del área de Ciencias de la Naturaleza. Los resultados indican que esos estudiantes, que están probando una práctica de iniciación a la docencia diferenciada, están sintiéndose más motivados y más capacitados para el ejercicio profesional futuro.

### **Palabras clave**

Formación de profesores de Ciencias de la Naturaleza; Epistemología de Ludwik Fleck; Construcción colectiva del conocimiento.

### **Introduction**

Current advances in science and technology have caused profound changes in social behavior, in communication, production processes, work organization and, consequently, the development of human resources. As a result, society has been demanding professionals who, in addition to technical competence, have engagement, initiative and decision-making capabilities (Maricato, Corazza-Nunes & Gianotto, 2000). If, as was stated by Baumgartner (2001), education has the potential to transform lives through the acquisition and utilization of knowledge and skills, the training of teachers should receive special attention. This training needs to consider that it must provide students and teachers with the skills to participate collectively in matters related to science, which have implications for their quality of life and that of the general population. As Hodson (2011) says, collective involvement in matters of environmental and social interest, based on studies and research, will increase knowledge about these matters and develop research and participatory citizenship skills.

In view of this, Barcelos (2000) warns that during their training, future teachers need to start the process of reshaping and reframing knowledge in order to construct the "knowledge of pedagogical action" from connections with their experiences and with the experiences of others. His assumption is that this will only be achieved through collective activities involving not only university students in initial training and their professors, but also teachers working in schools.

In this context, using a conception of collective construction of scientific and pedagogical knowledge, along with the epistemological view by Ludwik Fleck (1896-1961), can be an interesting alternative for the training of Science teachers. This author has been used as a reference in Brazilian studies regarding the history of science, and teaching (Delizoicov, 1999; Leite, Ferrari & Delizoicov, 2001; Scheid, Ferrari & Delizoicov, 2005; Scheid, 2006). This article discusses the contributions the activities developed in a Study Group of a program of post-graduation in scientific and technological teaching, which had Fleck's epistemology as theoretical reference, could add to the initial professional training process for future teachers from this area of knowledge.

Ludwik Fleck (1896-1961) elaborated an original contribution for the area of epistemology (Da Ros, 2000; Delizoicov et al. 2002b; Pfeutzenreiter, 2003; Scheid et al. 2005). One of the first to value it was Kuhn, when he affirmed that: “I have encountered Ludwik Fleck’s almost unknown monograph, *Entstehung und Entwicklung einer wissenschaftlichen Tatsache* (Basel, 1935), an essay that anticipates many of my own ideas” (Kuhn, 1962, p. vi-vii). This mention happened a year after Fleck's death and was the reason his text, published in 1935 and forgotten since then, received the attention of researchers and the intellectual public in general.

In order to argue that scientific research is socially and culturally conditioned, Fleck coined the expressions Collective of Thought and Style of Thought. The first designates a community of individuals that share practices, concepts, traditions and rules. Each Collective has a singular way of seeing and relating to knowledge, which is determined by their Style of Thought. The Style of Thought is characterized by the “common traces of problems that interest the Collective, by the reasons commonsense considers obvious and by the methods it employs as a means of knowledge” (Fleck, 1986, p. 145).

These arguments are part of the area of sociology and, thus, are not taken as reference for the training of Science teachers. Fleck proposes the identification of esoteric and exoteric circles in the structure of a Collective. The esoteric circle is formed by those that have direct relations with the product, that is, the specialists. Examples of possible esoteric circles in teaching courses would be the group of teachers of a specific area (botany, zoology, mechanics, organic chemistry, among others).

The exoteric circle is usually numerically larger than the esoteric circle. In it are the people who are not specialists.

Fleck states that an individual can belong to many circles simultaneously – some esoteric and other exoteric –, because “the complex structure of modern society causes Collectives of Thought to intersect and inter-relate in many ways, both in time and in space” (Fleck, 1986, p. 154). By belonging to many circles the individual acts in the transmission of ideas, which can be intracollective or intercollective.

It is intra-collective that in which there is dialogue among peers, based on readings and specialized publications, participation in events from that area of knowledge, among others. Usually, the transmission of ideas in the intra-collective sphere is highly fluent, since the members share the same Style of Thought. The dialogue between members of different esoteric circles causes an intercollective circulation of ideas. This circulation makes a difference in school since it promotes interdisciplinarity.

Fleck notes that the training of teachers has a decisive role in the assumption of a specific Style of Thought:

The type of work, the proposal of issues, the theoretical apparel and the practical application are acquired in the concrete phase of training, which is where students get to know the models and imitate them. [...] Tradition, education and habit create a disposition for feeling and acting according to a style, that is, directed and restricted feeling and acting. (Fleck, 1986, p. 31/131)

About this quote, Cutolo (2001, p. 59) infers that “teaching is introducing a Style of Thought and learning is entering a Style of Thought”. Even though the usual understanding of

teaching and learning refers to the teacher-student relationship, the author's statement is also valid for the relationship between expert-beginner. In both cases, the coherion exercised by the more experienced one – also called stylized eye of formative view – happens through didactic practices.

As stated by Delizoicov (1995), the dominant Style of Thought in the field of education, which underlies its conception of teaching and learning processes and is present in most teachers' pedagogical practices, may be a result from the academic training given to teachers that, when they have to perform their professional activities, “imitate the model” and act according to a style, in a directed and restricted sort of way, since “the introduction into a field of knowledge is more indoctrination than critical-scientific stimulus” (Fleck, 1986, p. 101).

The source of a Style of thought, according to Fleck (1986), is the circulation of ideas that can be intracollective or intercollective. Intracollective circulation happens through dialogue between peers, from the reading of specialized publications and the participation in meetings (congresses, seminars and others) of their specific field of knowledge. This dialogue is made easier because the members share the same style of thought (manner of seeing things, vocabulary, pedagogical practices, among others).

Intercollective circulation happens when there is dialogue between individuals from different esoteric circles. This circulation is important in educational institutions because dialogue between different areas promotes interdisciplinarity, and dialogue between different collectives – outside the circle – is also an important source for the construction of knowledge. The issues related to scientific education are currently becoming more complex by the day, and a discipline by itself can no longer account for all the adequate answers. In view of that, based on Fleck's theory, what is suggested is that the initial training for Science teachers takes into consideration the idea of collective construction of knowledge.

An important step towards the connection between different types of knowledge produced inside the area of Science, as well as between those resulting from it, is to create special forums for these discussions. This implicates the search for spaces for interdisciplinary studies and debates, since one area alone cannot provide all the answers. Levinson (2001) encourages collaboration between teachers from the areas of Science and Human Sciences, so as to account for the complexity of the issues emerged from them. We suggest the creation of Study Groups to stimulate intercollective circulation of knowledge.

### **Methodology for the creation of a Study Group for the exchange of knowledge**

In 2009, the Study Group "Critical Discussion of Research Articles on the Teaching of Science" was created. It follows the premise that everyone involved – university students, researchers, professors and school teachers - should feel responsible for creating ways of integrating the fields of knowledge, with the goal of making interdisciplinarity viable in order to construct the knowledge necessary for teaching. The main objective is to provide the academic community of the teaching courses for Biological Sciences, Mathematics,

Chemistry, and Masters in Scientific and Technological Education, as well as school teachers, with debates related to the teaching of Science, with the goal of strengthening the scientific bases and the construction of knowledge in this area of research.

This group is composed of students and professor from the post-graduation program in Scientific and Technological Teaching, students from Biological Sciences, Mathematics and Pedagogy teaching courses, scholars from the Teaching Scholarships, Scientific Research scholars, undergrad professors and school teachers. There are two monthly meetings, from March to November, on Friday afternoons. The meetings are coordinated by a professor from the post-graduation program.

This Study Group has been consolidating its activities by: i) Promoting readings and discussions about research articles on Science education; ii) Organizing debates based on socio-scientific and socio-environmental controversial issues, mentioned by Reis (2014), with the goal of understanding them from the positions of different areas of academic training; iii) Publishing contributions in events and scientific journals of the area. This way, this group, by the nature of the activities it develops, is being integrated into the Research Group of the Post-Graduation Program for Scientific and Technological Teaching.

It is important to highlight the participation of school teachers in this Study Group. Not only the academic knowledge produced in the university must contribute to these teachers, but their experience with daily work in schools equally provides important contributions to be explored theoretically. The latter, according to Gauthier *et al.* (1998), is the knowledge from experience. The school teacher who, for reasons that are not ours to judge, is demotivated, can, with this interaction with the academic environment, rediscover their “experience knowledge, which is the core of the teaching knowledge, a core from which teachers try to transform their exterior relations with the knowledge from within in their own practices” (Tardif, 2002, p. 54). In view of this, it is observed that the participation of these teachers in the Study Group is having a revitalizing effect in their teaching practices, because it allows them to revisit their practices and incorporate new theoretical reflections. This observation corroborates the following statement by Rozenszajn & Yarden (2010, p. 81), who said “teachers are able to take what they have learned from a professional development course and incorporate it into an ongoing program”. This revitalization is causing the recognition of society and of their identity as teachers.

Giving special attention to these teachers is justifiable because, one way or another, they will be the Dar “guides” for the university students when they initiate their professional practices, when they transition from students to teachers and create their professional identity.

The guiding principle for the activities in this Study Group has the theory by Ludwik Fleck (1986), presented before, as its epistemological base. Based on the categories created by this epistemologist of Science, the Study Group believes that a continued training is not accomplished alone, in an individual manner. However, it cannot be denied that the best opportunities for perfecting teaching competence are in the individual search for support, reflections and study. In view of this, although it is a collective work, individualities must be respected. It is necessary that each member is viewed as a person with a unique life story, in different stages of training or of their professional lives. Yet, these individuals have in

common the concern with improving the quality of scientific education and the civic education of the students. Therefore, more than looking **to** one another, it is important to look **with** one another at the complexity of the teaching and learning processes regarding Science in the current socio-historic, economic and cultural context in which we are implicated (Scheid & Casagrande, 2007).

The group dynamics is benefitting greatly from publications by scientific associations regarding issues of teaching, because they encourage activities by circulating ideas among different fields of knowledge, originating, in many occasions, common interests. These associations are the Brazilian Chemical Society (SBQ), the Brazilian Physical Society (SBF) and the Brazilian Society for the Teaching of Biology (SBENBIO).

The oldest of the associations is the Brazilian Chemical Society (SBQ), which was founded in 1922. This scientific society has the goal of developing and consolidating the Brazilian chemical community, promoting Chemistry and its important relations, applications and consequences for the development of the country and for improving people's quality of life. On the fourth article of its statute, the SBQ states that it has the goal of joining chemists and other professionals and institutions linked to Chemistry in order to develop, integrate, publish and promote the responsible research, education and application of chemical knowledge, aiming to constantly increase the excellence of Chemistry in all its aspects, as a way of boosting human and socio-economic develop in Brazil and around the world.

The SBQ has 13 scientific divisions that join the associated members in the different Chemistry areas where they act. Among these divisions, the Chemistry Teaching Division was the first to become official, which happened during the association's 11<sup>th</sup> Annual Meeting, in July 1988. This division has promoted many National Meetings for the Teaching of Chemistry, and publishes the journal "*Química Nova na Escola*" ("New Chemistry in School"). The aim of this journal is to provide the Chemistry Teaching community with work, formation and updates. It is a space that is open to teachers, encouraging debates and reflections about teaching and learning Chemistry.

The Brazilian Physical Society (SBF) was created in 1966, during the 18th Annual Meeting of the Brazilian Society for the Progress of Science (SBPC), which took place in Blumenau, in the state of Santa Catarina. Researchers, school teachers and Physics students participated in this conference. On the second article from its statute, the SBF lists the following goals: to join the Brazilian physicists and Physics teachers; to protect teaching and research freedom, and the interests and rights of the physicists and Physics teachers; to protect the prestige of Science in Brazil; to encourage research on Physics; to encourage improvements in the teaching of Physics on all levels; to maintain contact with related institutes and societies, both Brazilian and foreign; to encourage and promote exchanges between Brazilian and foreign professional; to promote scientific meetings, specialized congresses, conferences, courses and activities; publish journals with scientific and didactic studies from the field of Physics; publish bulletins about the activities of the Brazilian Physical Society and about general subjects related to developments in Physics; to encourage the publication of Physics knowledge, by publishing books, texts, dissertations, as well as through the press, radio, television and internet; to encourage better profiting and

distribution of scientists in the field of Physics, as well as better planning for producing necessary specialists for the development of the country.

In the area of teaching, the SBF has been promoting scientific events since 1970, when it promoted the First National Symposium for the Teaching of Physics. Among the publications by this association, the ones concerning the area of teaching are the “Revista Brasileira de Ensino de Física” (“Brazilian Journal for the Teaching of Physics”) “focused on the improvement of the teaching of Physics in all education levels. By publishing high-quality articles, reviewed by two people, the journal promotes Physics and related sciences, contributing for the scientific education of society as a whole. It publishes articles about theoretical and experimental aspects of Physics, instructional materials and methods, curriculum development, research on teaching, history and philosophy of Physics, educational politics and other pertinent subjects to the community interested in Physics teaching and research” (SBF website, 2012). Since the year 200 it publishes the “Física na Escola” (“Physics in School”), a bianual supplement of the “Revista Brasileira de Ensino de Física” journal, which supports the activities of school Physics teachers.

The Brazilian Society for the Teaching of Biology (SBENBIO) is a nonprofit civil society of scientific and cultural character, established in 1997. It aims to promote the development of the teaching of Biology and of research on the teaching of Biology among professionals of this field of knowledge. Varied profiles are among the associates: school teachers and university professors, undergraduate biology students and researchers from the areas of teaching of Biology and Sciences, including professors, undergraduate and graduate students. In July 2005, it promoted the "First National Meeting for the Teaching of Biology", at the Federal University of Rio de Janeiro. The regional divisions have organized "Regional Meetings for the Teaching of Biology" (EREBIOS), and the results of all these events are published in their Annals. It can be said that all these scientific events are a space for the reflection and discussion among professionals involved in the teaching of Biology, as well as a new way to update teachers. Since 2005, the association maintains a journal, “Revista da SBENBIO” (“Journal of SBENBIO”), which publishes articles referring to biology teaching, covering all levels of education.

It is important to have in mind that in addition to the contribution of the SBQ, the SBF and the SBENBIO, other associations, which also promote meetings, seminars and conferences, promote the training of teachers of the area of Science. Among them, one cannot fail to mention the "Annual Meeting of the Society for the Progress of Science" (SBPC), the "National Meetings for Research on Science Education", promoted by the Brazilian Association for Research on Science Education (ABRAPEC), and the Brazilian Society of Genetics (SBG), which, besides being essential for the exchange of knowledge between experts and researchers in this specific area, in recent years has also paid attention to teaching. In 2006, the Society created, through the Genetics Teaching committee, the electronic journal “Genética na Escola” (“Genetics in School”), published every six months. This journal disseminates educational experiences in the field of genetics, whether innovative practices or methodological approaches, in order to reflect upon genetic concepts and discuss the impacts of technology on the quality of life of the population, and publish materials to be used in the classroom.

## Results and discussions

We understand as essential for the training of teachers that collaborative and interactive activities are promoted, with communication between teachers in training, and of these teachers with their professor and researchers from different areas of the field. In view of that, the members of the Study Group, besides being presented to the publications, are encouraged to participate in the events promoted by these scientific associations, because these are systematic practices that can make this process easier. Besides the formal communication about experiences and research in the area, which are priceless, it is necessary to consider the richness of informal exchanges that happen between the participants in these events. The different styles of thought or, simply, the different shades of styles of thought (Fleck, 1986) of the participants in these events converge to a common point: the improvement of the teaching of Science.

On the other hand, many school teachers who cannot participate in these events find in these publications an important source for consultation, reflection and exchange with the authors from the articles. This becomes a valuable instrument for making the continued training of these teachers viable. University students, in turn, have a unique opportunity to converse with working teachers, an exchange of knowledge that is important for both.

The interest for disseminating, including to school teachers, the knowledge produced regarding the teaching and learning of Science is validated by the statement by Delizoicov, Angotti and Pernambuco (2002). According to these authors, if one considers the investigation objects and the quality of studies in the area of Science, Brazilian production can be compared to that of more developed countries. The dissemination of results among peers is considered to be satisfactory, given the high number of conferences, journals for publication and mutual references used. However, there is cause for concern in the incipient appropriation, reconstruction and systematic debate about the results of the studies in the classroom and on the teaching practices which, in the three levels of education, leave much to be desired. This gap between groups of researchers and teachers collectives makes it more difficult to achieve the desired improvement in the teaching of Science, and is an important challenge for all those involved with the training of teachers from this area.

Participating in different events of the area gives the student the possibility of knowing the more recent productions – scientific, technologic, or connected to the teaching of relevant scientific subjects -, and also of reflecting upon their contribution for the progress of humanity and the improvement in quality of life. If epistemological support is given to students during their initial training, they will be able to comprehend that Science is not only a product used in order to discover facts and establishing general concepts, but a process and an institution (Krasilchik; Marandino, 2004). Thus, they will be able to understand that the effects of contemporary science and technology offer advantages, but can cause problems, so their meanings in the current contexts need to be understood. The ethical and social problems that have emerged over the las decades need to be related to the world views that underlie the processes of construction of knowledge and decide how their results will be used.



## Conclusions

In this context, the collective activities developed in the Study Group are in accordance with the statement by Fleck (1986, p. 154), who said that “the complex structure of modern society causes Collectives of Thought to intersect and inter-relate in many ways, both in time and in space”. Communication between collectives of thought can happen through teaching, since this is one of the ways to ensure the dominant style of thought will be shared. Besides that, it is through teaching that individuals are introduced into a certain style of thought so they can be accepted as members of a certain collective of thought. However, an individual in their scientific or training activities is not member of only one circle of knowledge, confirming the importance Fleck gives to the relationship among circles of knowledge (esoteric and exoteric). This statement corroborates the importance of promoting collective activities during scientific and teaching training, so the training given to Science teachers is qualified. According to Parke & Coble (1997), promoting teachers’ professionalism with acquisition of academic knowledge and participation in collaborative workshops, like study groups, may empower them to become more thoughtful about their profession.

However, it is not enough to have qualified teachers in order to achieve an adequate scientific training and ideal initiation to teaching, because many other causes contribute to the concern regarding the quality of Science education. Indeed, searching for better conditions is our part as the professionals responsible, at least partly, for the training of teachers in this area, who will promote scientific and civic education in different educational circles. We need to re-evaluate the curriculums, the pedagogical practices, the time and the spaces of educational institutions, with the goal of promoting the dialogue between different types of academic knowledge, researchers, professors and school teachers, through collective activities. This statement comes from the results obtained until the moment, which indicate that these students, when experiencing a qualifies initiation to teaching, are feeling more motivated and better able to exercise their professions in the future.

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